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PATENT
P-3068-US

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT(S): YONA, Zvi et al.

SERIAL NO: 09/818,575 EXAMINER: Unknown

FILED: March 28, 2001 GROUP ART UNIT: Unknown

FOR: PERSONAL DISPLAY SYSTEM WITH EXTENDED FIELD OF VIEW

ASSISTANT COMMISSIONER OF PATENTS
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WASHINGTON, DC 20231

CLAIM FOR PRIORITY

Sir:

Applicant(s) hereby claims priority under 35 U.S.C. Section 119 based on Israeli Application No. 135334 filed March 28, 2000.

A certified copy of the priority document is submitted herewith.

Respectfully submitted,

Vladimir Sherman
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Dated: April 12, 2001

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משרד המשפטים
לשכת הפטנטים

This is to certify that annexed hereto is a true copy of the documents as originally deposited with the patent application of which particulars are specified on the first page of the annex.

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This 20-12-2000 היום

רשם הפטנטים

Commissioner of Patents

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Certified

חוק הפטנטים, התשכ"ז - 1967
PATENTS LAW, 5727 - 1967

בקשה לפטנט - Application For Patent

לשימוש הלשכה
For Office Use

מספר: Number	135534
תאריך: Date	28-03-2000
הוקדם/נדחה Ante/Post-dated	

אני, (שם המבקש, מענו ולגבי גוף מאוגד - מקום התאגדותו)
I, (Name and address of applicant, and in case of body corporate - place of incorporation)

אלביט מערכות בע"מ
חוף הכרמל
ת.ד539 .
חיפה31053

חברה ישראלית

ELBIT SYSTEMS LTD.
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P.O. Box 539
Haifa 31053

Israeli Company

בעל אמצאה מכח **הדין** ששמה הוא
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(בעברית) (Hebrew): **שיטה והתקן ליצירת שדה ראיה רחב לקסדה**

(באנגלית) (English): **METHOD AND APPARATUS FOR CREATING A LARGE FIELD OF VIEW FOR A HELMET**

*בקשת חלוקה - Application of Division	*בקשת פטנט מוסף - Application for Patent Addition	דרישה דין קדימה Priority Claim		
*מבקשת פטנט from Application	*לבקשה/לפטנט to Patent/Appl.	מספר/סימן Number/Mark	תאריך Date	מדינת האגוד Convention Country
מס' No.....	מס' No.....			
מיום dated.....	מיום dated.....			
יפוי-כח: POA:				
הוגש בענין filed in case **P.A.99420**				

המען למסירת מסמכים בישראל
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איתן, פרל, לצר וכהן-צדק
עורכי דין, עורכי פטנטים ונוטריון
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היום 28 לחודש מרץ שנת 2000
This 28 of March of the year 2000

חתימת המבקש Signature of the Applicant

עבור המבקש, For the Applicant,

איתן, פרל, לצר וכהן-צדק
EITAN, PEARL, LATZER & COHEN-ZEDEK
P-3068-IL

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* מחק את המיותר Delete whatever is inapplicable

METHOD AND APPARATUS FOR CREATING A LARGE FIELD OF VIEW FOR A HELMET

שיטה והתקן ליצירת שדה ראיה רחב לקסדה

Eitan, Pearl, Latzer & Cohen-Zedek

P-3068-IL

BACKGROUND OF THE INVENTION

It is often desirable to display off of the visor of a helmet an optical image. This is generally useful for applications such as flight borne helmets where the pilot (the viewer) desires to see pictures or symbols reflected off the visor.

Reference is now made to Fig. 1. The helmet typically comprises an image source 30 and relay optics 10. A picture is relayed from source 30, through optics 10, reflected off a visor 15 or combiner element, and into the person's eye, such as a pilot. The typical field of view (FOV) as received by the pilot is 40°*. Increasing FOV with the present concept requires a reduction in resolution, and a substantially larger and heavier relay optic and helmet. As an example, in order to achieve a 60°* FOV, the relay optics must be heavier.

LIST OF DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

Fig. 1 is a schematic illustration of a prior art optical image display on a helmet;

Fig. 2A is a schematic illustration of the optical image display on a helmet in accordance with a preferred embodiment of the invention;

Fig. 2B is a schematic illustration of a time sequential of the operation of the apparatus detailed in Fig. 2A;

Fig. 3 is a schematic illustration of an alternative embodiment of the present invention;

Figs. 4A and 4B are schematic illustrations of detailed views of two options for Device D of Fig. 3;

Fig. 4C is a schematic illustration of a detailed view of the option for Device B of Fig. 3;

Fig. 5 is a schematic illustration of a further alternative embodiment of the present invention;

Fig. 6 is a schematic illustration of an alternative embodiment of the present invention;

Figs. 7 and 8 are schematic illustrations of a combination of the multiple image reflection embodiments of Figs. 2 - 5 with the diffractive optics of Fig. 6.

Appendix A

Appendix B.

A DETAILED DESCRIPTION OF THE PRESENT INVENTION

An image is produced by image source 30, received by relay optics 10, deviated/reflected at a high speed in more than one direction by device A, and superimposed in visor 15 in not less than one location. The images, from the more than one location, reflect off the visor 15 and are received by the eye of the user. Since the switch between the different locations happens at such a high speed, the eye does not detect switching, and the FOV is increased from the prior art maximum of 40° to 80°.

Fig. 2A illustrates two such images, an image 101 reflected to the left and an image 201 reflected to the right. Both are received as one by the eye of the user, resulting in a wider field of view than that of each image signally. It is noted that this embodiment is capable of producing multiple images, and hence multiple different locations.

Device A is one of :

tilting mirror, or

electro-optic lens - liquid crystal based diffractive lens, which receives electrical impulses for different reflective or deviated angles (example Digi-lens,Hologram) or

DMD or DLP montation or similar with two stages (black & white pictures)

Device A: Movement non-detectable by the eye using a repetition rate of 25 mill-seconds or less. Time transition in milli-seconds. Synchronized with the image source. The eye performs time integration to receive the large FOV. It is useful to note that according to the present invention, in order to achieve a wider FOV, the helmet experiences a weight increase of only about 10% .

Reference is now made to Fig. 2B, a time sequential of the operation of the apparatus detailed in Fig. 2A. Note that the top line depicts the selective images produced by image source unit 30, first image 101 and second image 201, and the

bottom line depicts the reflective position of the device A, image 101 to the left and image 201 to the right.

Fig. 3 depicts an alternative embodiment of the present invention. The functions of image source 30 are replaced with device D (image source 40), and the functions of device A are replaced by device B, is a wedge with two reflecting surfaces, one with polarization P and the other with polarization S. It is noted that since device B has only two reflecting surfaces, the number of projected images and angles is limited to two, in contrast to the system depicted in Figs. 2, which allow projection of multiple images. The time line as depicted in Fig. 2B is applicable.

Figs. 4A and 4B depict detailed views of two options for Device D. Fig. 4A depicts a synchronized source which allows time integration of the images like LCO device with one polarizer, while Fig. 4B depicts two internal image sources, source P and source S. The device depicted in Fig. 4B allows for space integration of the images. The image source may be any type of display technology by using P&S polarizers or LCD technology by its original light modulation via light polarizing.

Fig. 4C depicts a detailed view of the option for Device B, an optical prism with S" and P" reflector on each surface. Device B is operated such that the S" image from the relay optics 10 is reflected in the S" direction via the S" reflector. Similarly, the P" image passes through S" reflector and is reflected via P" reflector to the other direction. The P" and S" images are generated in a time domain sequential manner.

Using other polarized angles (not 90°) can manipulate more than two images but requires more polarizers to cut the undesired polarized images.

Fig. 5 depicts a further alternative embodiment of the present invention. The functions of image source 30 are replaced with an image source 50, and the functions of device A are replaced by a device E, a wedge with two reflecting surfaces, each one at different wave length, providing for ability to produce color images. Image source 50

produces images at difference wavelengths, allowing for wave length integration. The time line as depicted in Fig. 2B is applicable.

It is noted that embodiment depicted in the Fig. 2A provides time integration of the produced image. Conversely, the embodiment depicted in Fig. 3 along with Figs. 4A and 4B allow for integration and space integration. Lastly, the embodiment depicted in Fig. 5 allow for wavelength integration.

Reference is now made to Fig. 6, an alternative embodiment of the present invention. Fig. 6 depicts a visor 115 having diffractive optics formed therein. Since the visor 115 is the last optical element before the eye, improving this element (the visor) improves the system performance. Additionally, by adding the diffractive optics to the visor, it is possible to remove some of the optics from within relay optics 100, creating a lighter unit. The eventual composition of relay optics 100 depends on the choice of diffractive optics formed into the helmet, and on the synergism therewith.

Techniques to produce diffractive lens from/on the visor:

etching

diamond turning

lithography

molding

Using the same optical relay to achieve a non-distorted wide-FOV imagery, the field correction can be done by reverse-image correction manipulation on the image source such that the projected image to the eye will be non-distorted. Or the correction can be done on the reflected element 15 (visor/combiner) by using a powered reflected optical element such as diffractive, hologram, binary optics.

The image correction can be done by a mixed element part on the source (usually by display electronic device) or through the optical relay and/or the visor/combiner.

Figs. 7 and 8 depict a combination of the multiple image reflection embodiments of Figs. 2 – 5 with the diffractive optics of Fig. 6. Each of the embodiments in Fig. 7 and 8 additionally comprise a device C, an electro-optic lens synchronized with the image source will enable the correction of the image differently at different time/projection areas.

As depicted in Fig. 7, each diffractive lens 210, 220 or 230 can correct the image differently to enable the use of the same relay optic to project at different areas.

Further explanations concerning the present invention are present in Appendixes A and B, below.

APPENDIX A

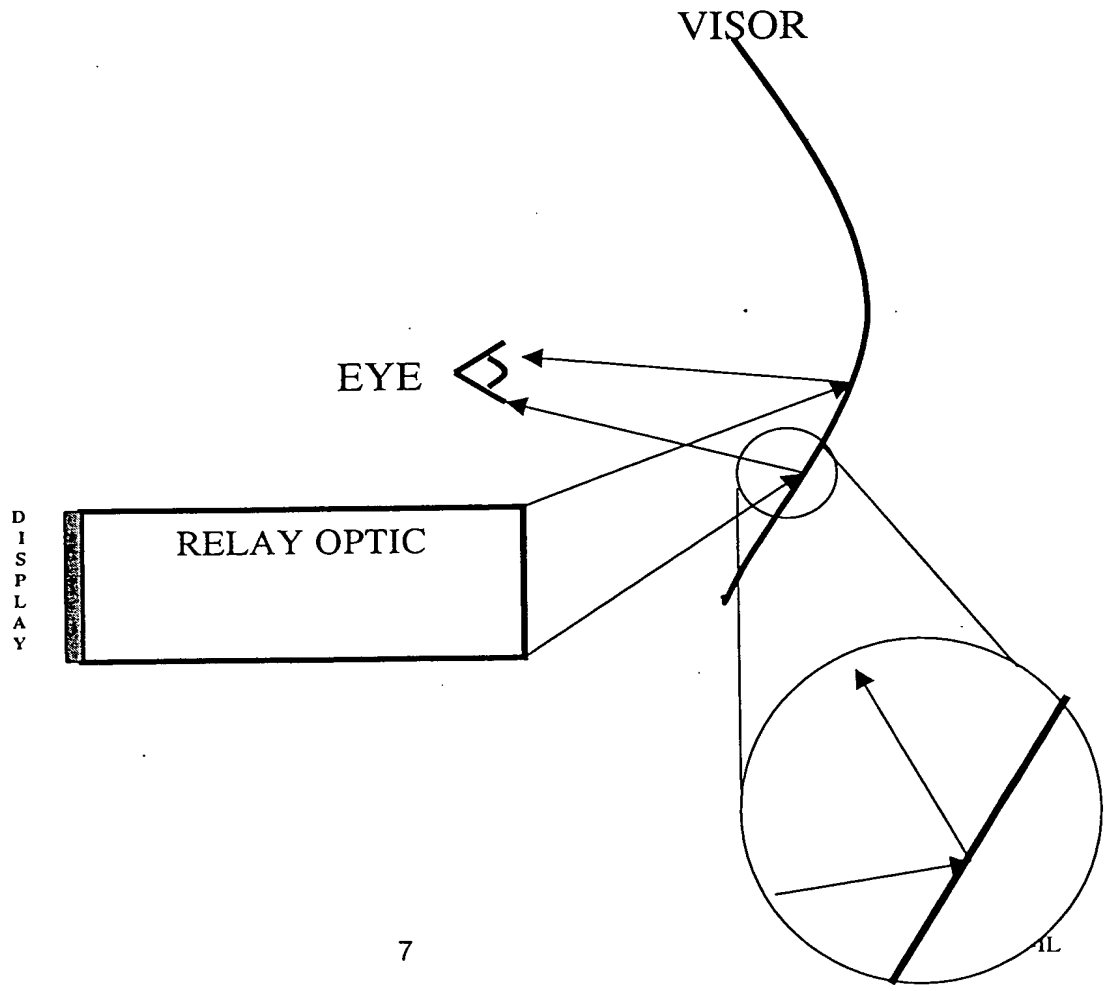
PATENT PROPOSAL

Abraham Sasson, Arlievsky Aron, Shalom Shmuel,
Hamburger Oded, Yona Zvi,

Create a Large FOV in Helmet Mounted Display System by Using of "Smart" Visor

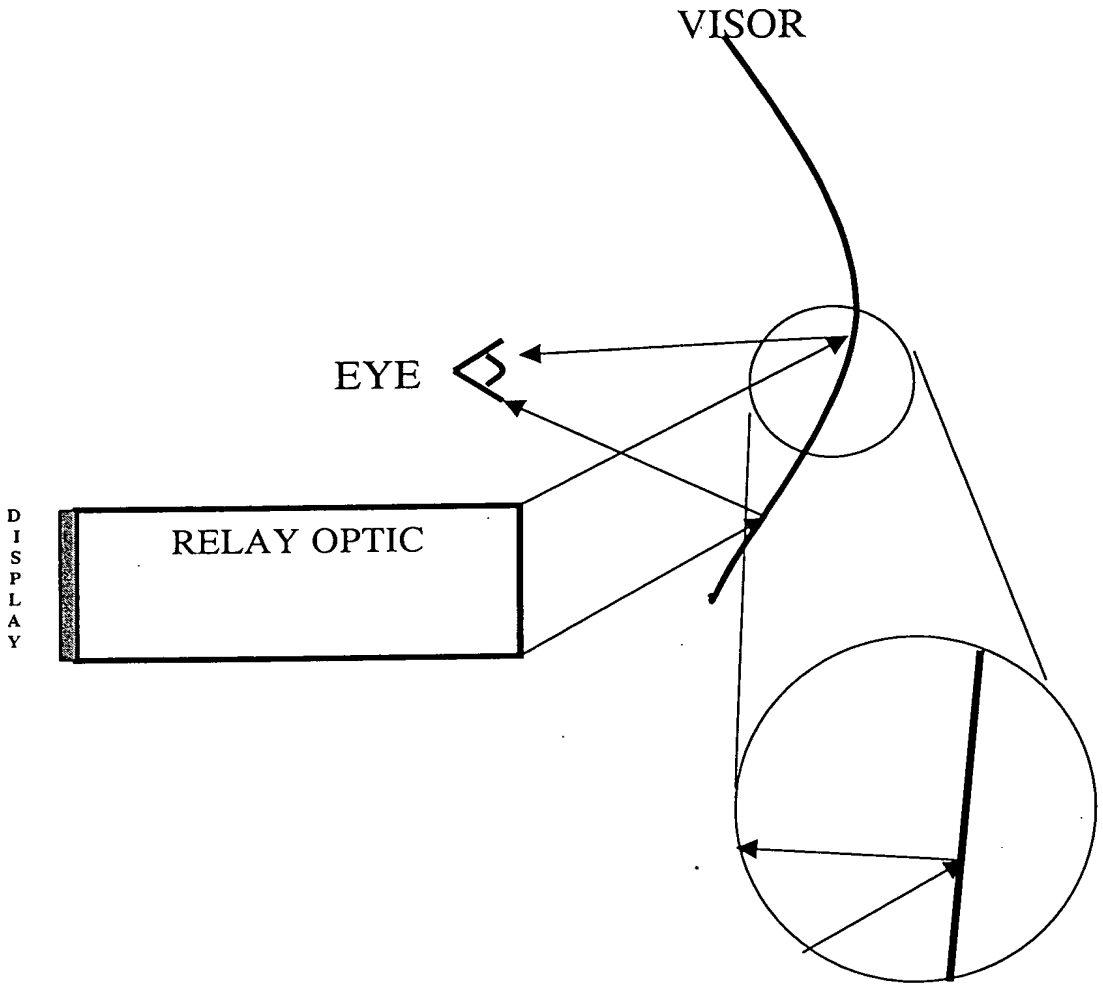
The HMD prior art optical system using a visor as the last element of a HMD system-the visor is an optical combiner when the image is reflected from the inner visor surface to the user eye, while allowing see through the surrounding scenery. The use of a spherical shaped visor is allowing to adjust the reflected image to verity of users (IPD accommodation), but in the other hand reduces the FOV of the displayed image to the eye, due to aberrations introduced by the visor shape. Correcting the aberrations by optimizing the optical channel system lenses will lead to very complicated lens shape and a manufacturing limitation.

The proposed invention is to implement a diffractive or adaptive shaped surface on the visor reflected area, in such a way that any assigned image ray shall be reflected to the desired location, in spite of the relevant reflection angle generated by the snal low.



The visor shape can be spherical, parabolic, even toric . The diffractive semi mirror surface can be implemented by engraving, etching, lithography process or diamond turning. Each of this process can be achieved by pre-visor mold tool or optical insert to a complete visor.

The mirror shape will be optimized and will lead to reduce high order aberrations, and will enable enlarging displayed FOV and/or reduce the all system weight.



This innovative approach allows flexibility with the optical relay location and size for high helmet conformity.

This approach allows generating two or more special surfaces on the visor in such a way that the same optical relay can generate a panoramic image. The sub-images can be modulated by wavelength, polarizing, or time domain sequencer.

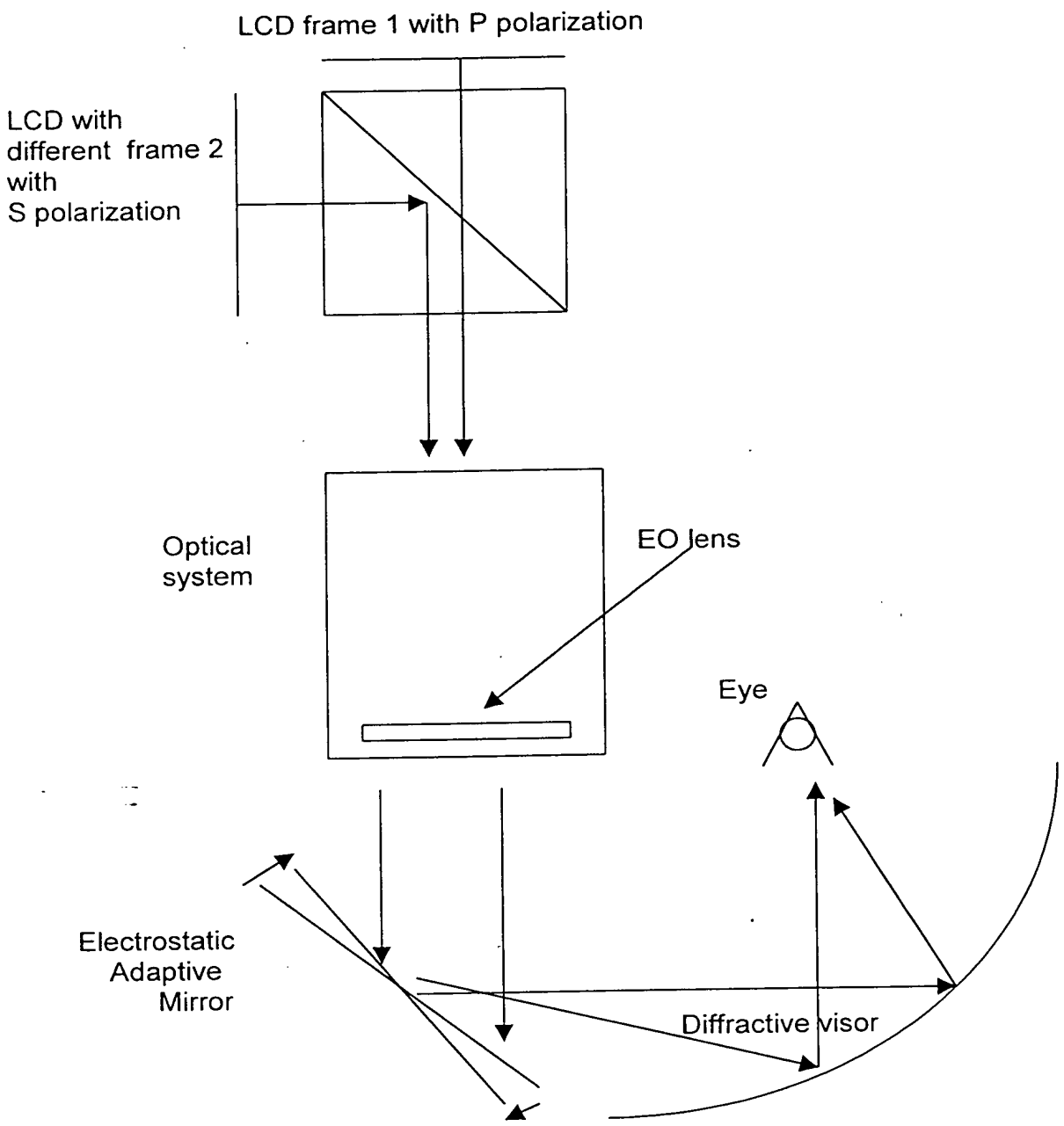
APPENDIX B

The idea is to utilize the same optical system with or without an adaptive electrostatic lens for two different images reflected at different angles to the eye.

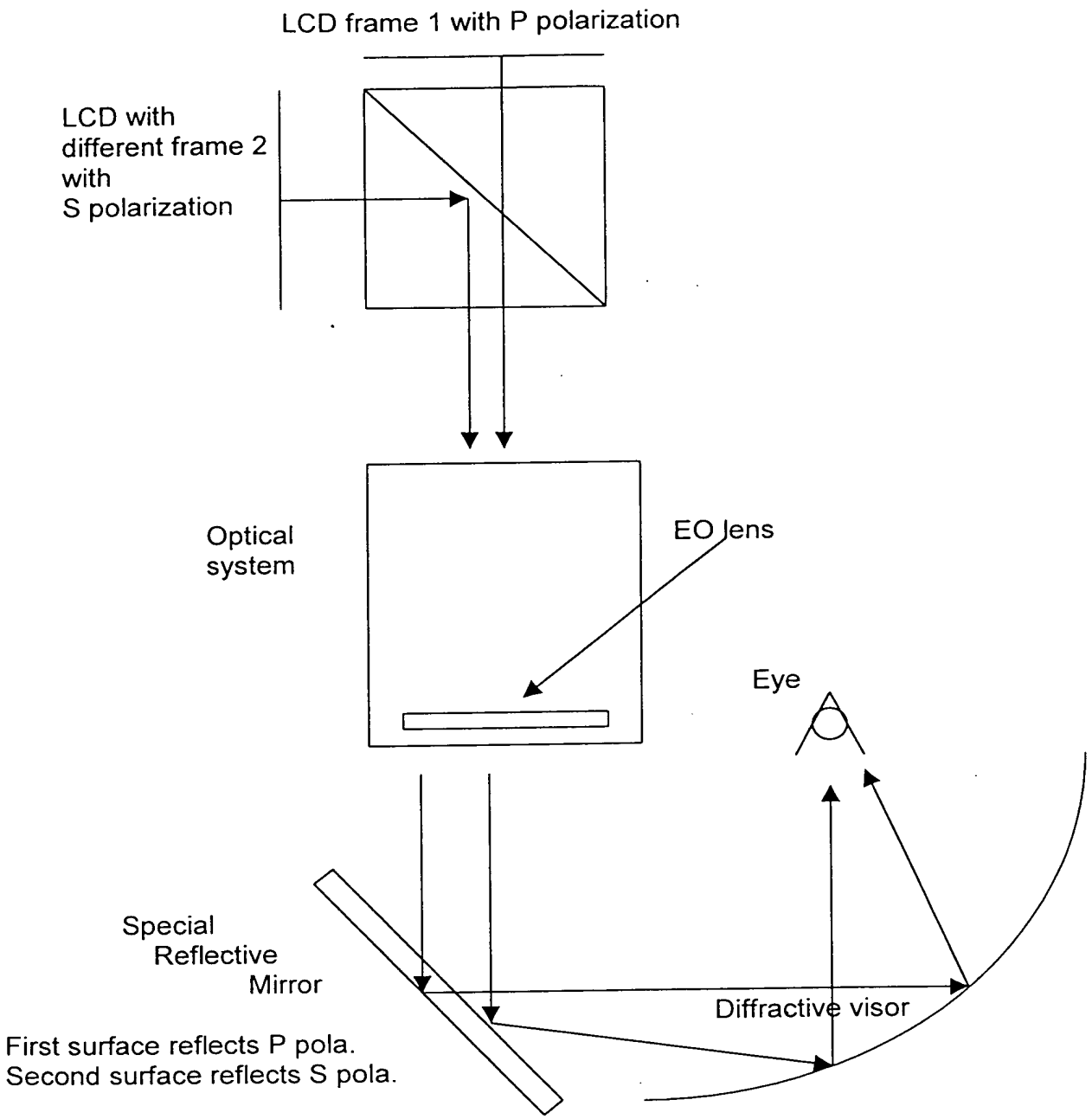
Trying to display two different FOV, which will overlap with a certain amount of %, the system will give a large apparent FOV utilizing optics for smaller FOV's.
One frame for the first FOV will be displayed at P polarization and reflected to a given position on the visor. The second frame for the second FOV will be displayed at S polarization and reflected on another visor position.
Some different aberrations of the two channels can be corrected with the EO Lens or on the visor by different diffractive shape.
The polarization is not evident: if we can synchronized two LCD with the tilting mirror/s, the polarization is not primordial.

This idea will lead to wide FOV's , smaller and lighter optics.

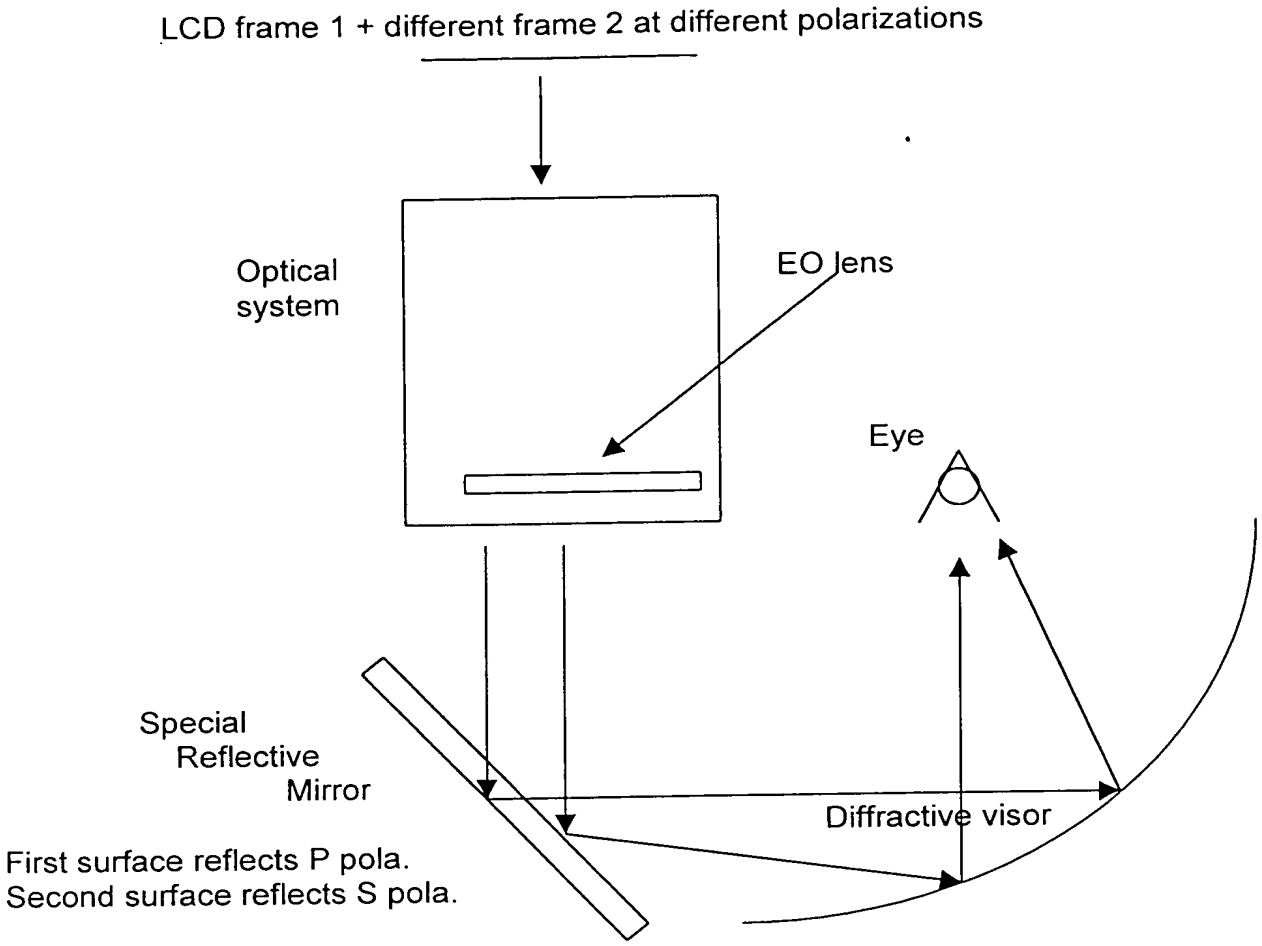
Two polarized LCD - tilting mirror



Two polarized LCD - static special coated mirror

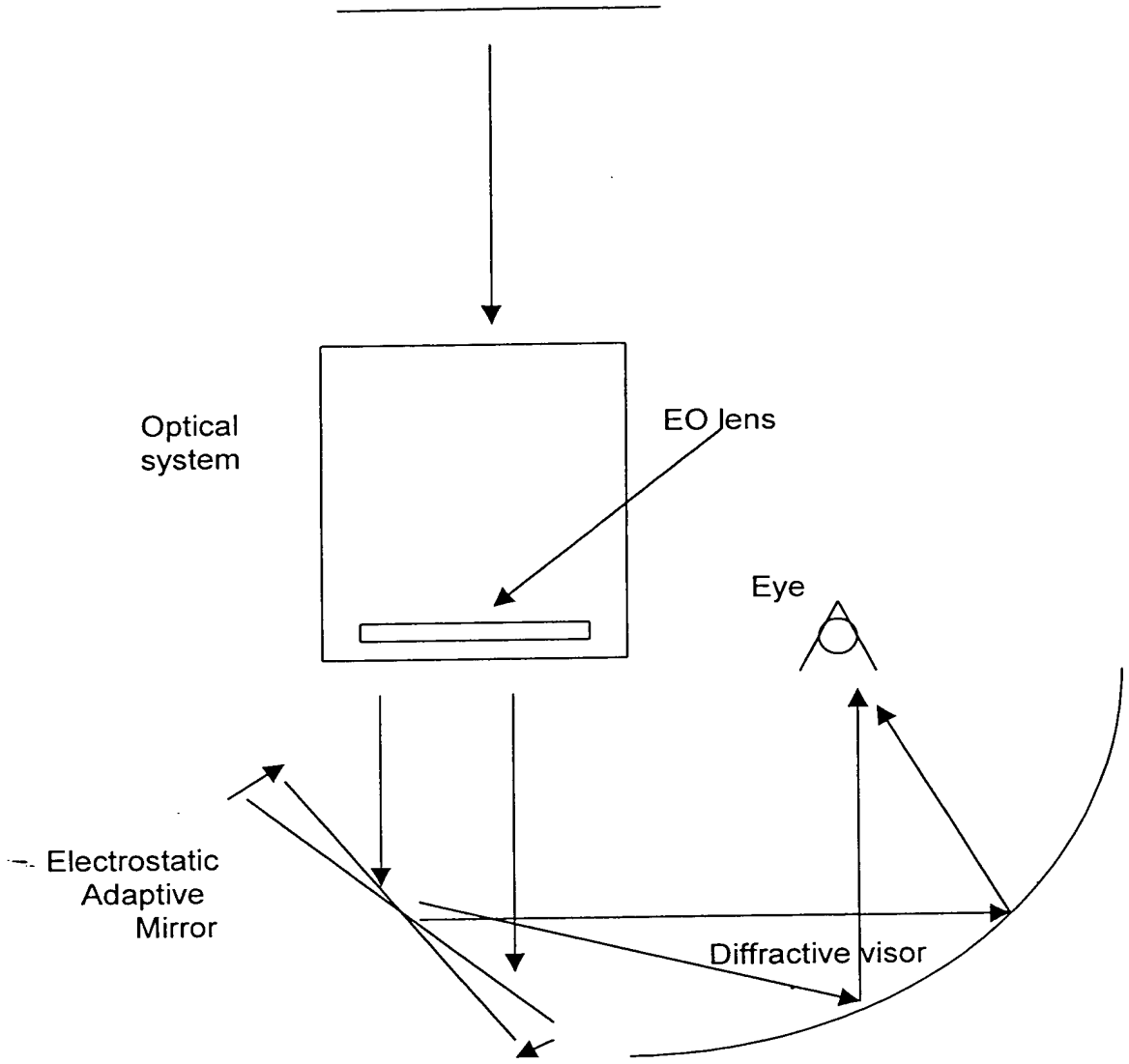


One LCD polarization changed in the system - special mirror


LCD frame 1 + different frame 2 at different polarizations
Optical system
EO lens
Eye
Special Reflective Mirror
Diffractive visor
First surface reflects P pola.
Second surface reflects S pola.

One LCD - tilting mirror

LCD frame 1 + different frame 2 synchronized with the tilting mirror



It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow:

CLAIMS

1. Apparatus for increasing the field of view of an image reflected off a combiner, the apparatus comprising:

an image source for producing said image;

relay optics having a first field of view, for optically transferring said image; and

a reflective unit for selectively directing said image to said visor at at least two angles, said reflective unit switching between said angles at a speed and time domain such that the resultant field of view at said visor is wider than said first field of view.

2. Apparatus for increasing the field of view of an image reflected off a visor, the apparatus comprising:

an image source for producing said image;

relay optics having a first field of view, for optically transferring said image; and

a reflective unit for selectively directing said image to said visor at at least two angles, said reflective unit switching between said angles at a speed and time domain such that the resultant field of view at said visor is wider than said first field of view.

3. A visor having diffractive optics formed therein.

4. A visor according to claim 3 wherein said diffractive optics is binary optics, holograms or optic-powered implemented optics.

5. A helmet for providing an image to a user, the helmet comprising:

an image source for producing said image; and

optical unit for processing said image and for providing said image to said user, wherein said optic unit comprises:

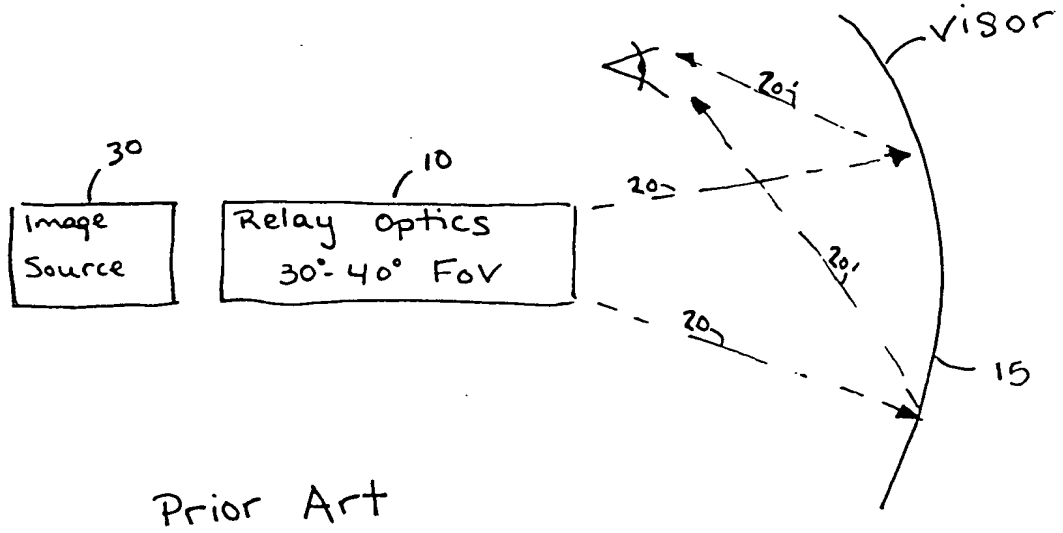
relay optics for performing a first portion of said processing, and

a visor having diffractive optics for performing a first portion of said processing.

For the Applicant

Eitan, Pearl, Latzer & Cohen Zedek
Advocates, Patent Attorneys & Notaries
P-3068-IL

Around 40° FOV Relay Optic



Prior Art

Fig. 1

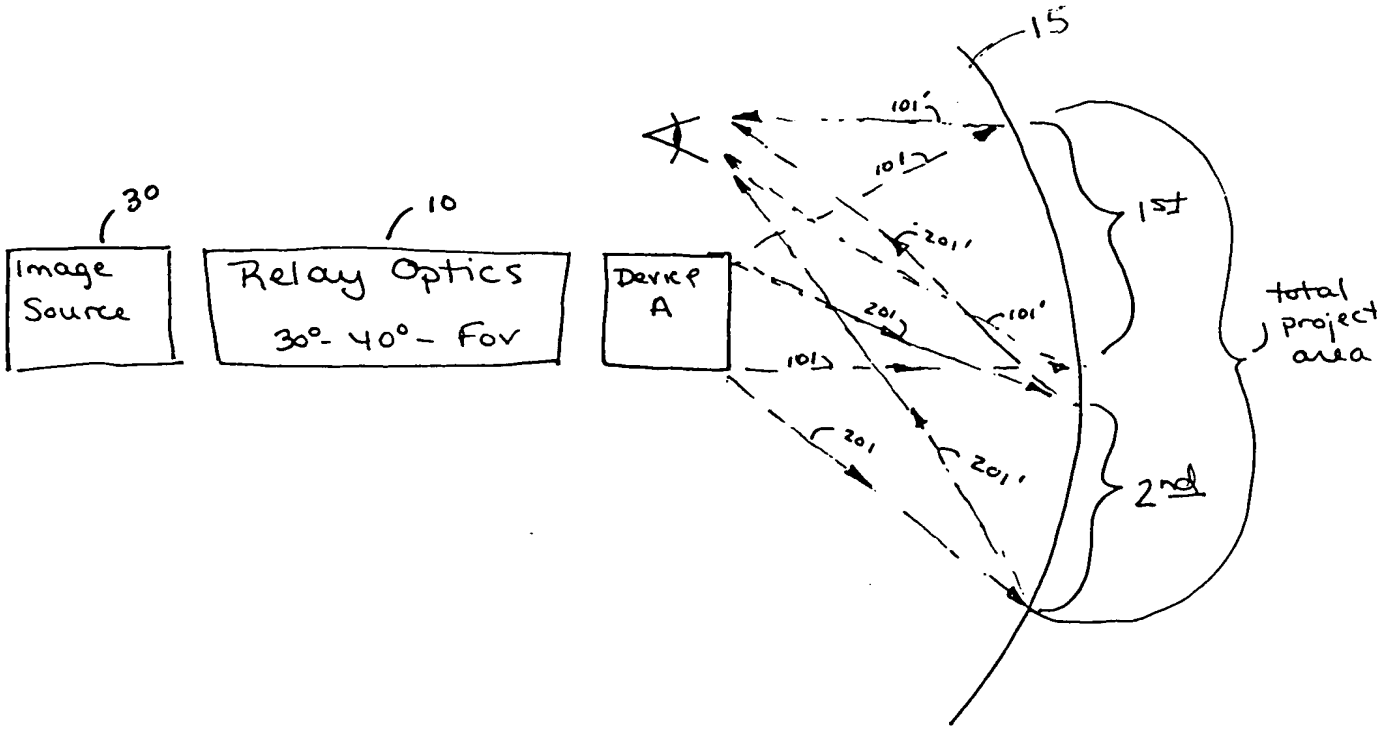


Fig. 2A

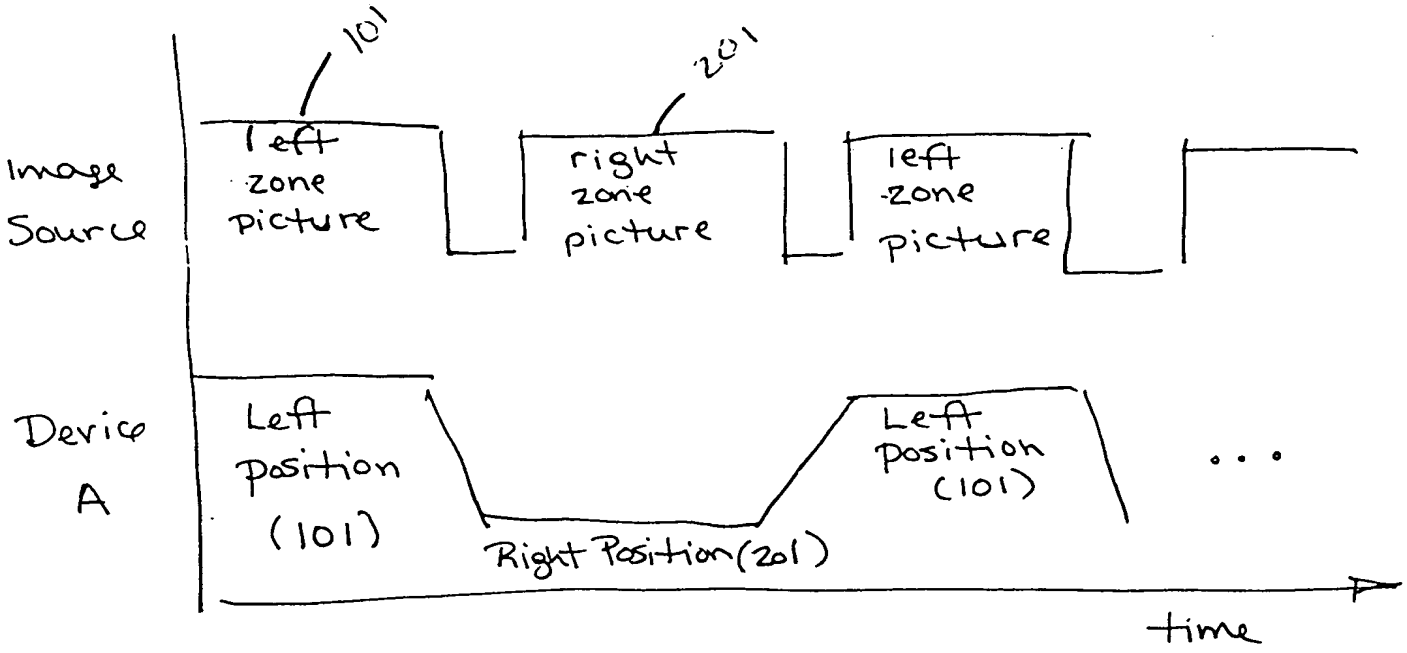

101
201
Image Source
left zone picture
right zone picture
left zone picture
Device A
Left position (101)
Right Position (201)
Left position (101)
...
time

Fig. 2B

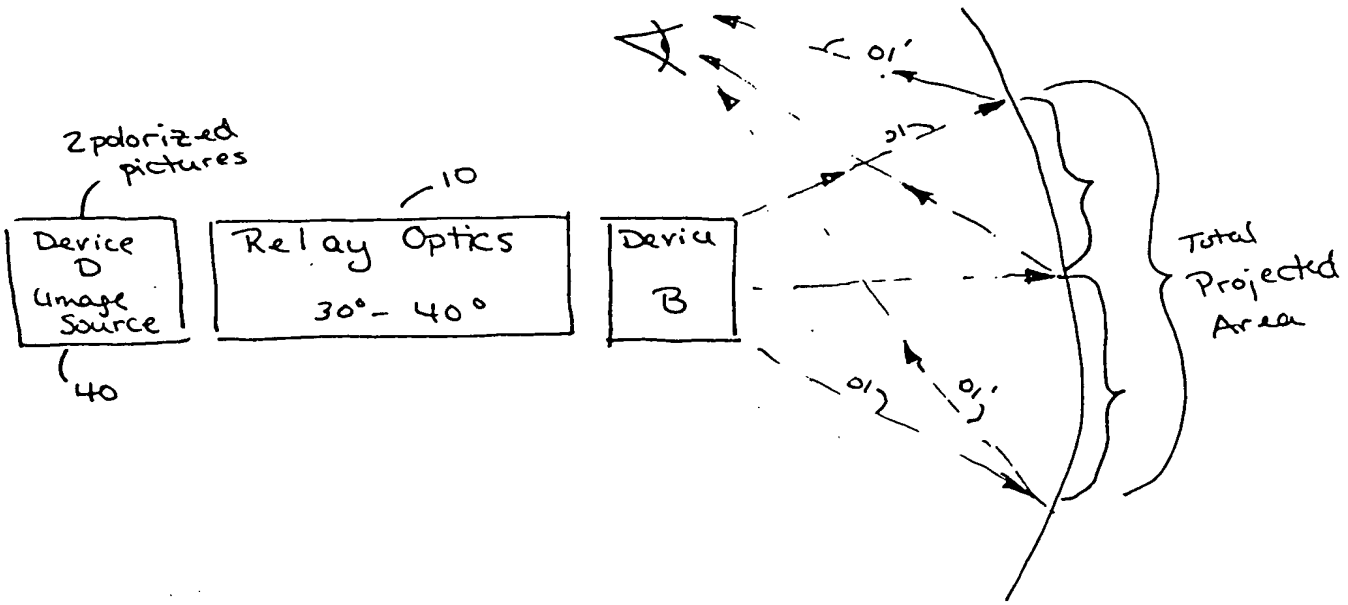

2 polarized pictures
Device D Image Source
40
10
Relay Optics
30° - 40°
Device B
Total Projected Area

Fig. 3

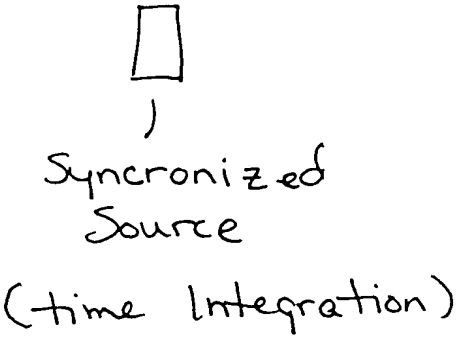


Fig. 4A

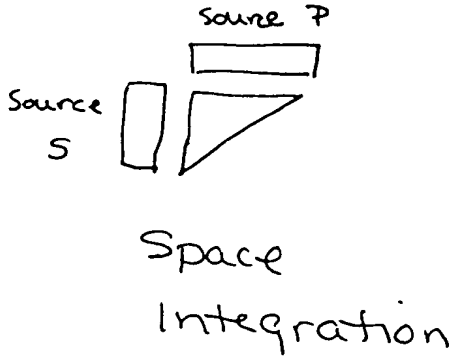


Fig. 4B

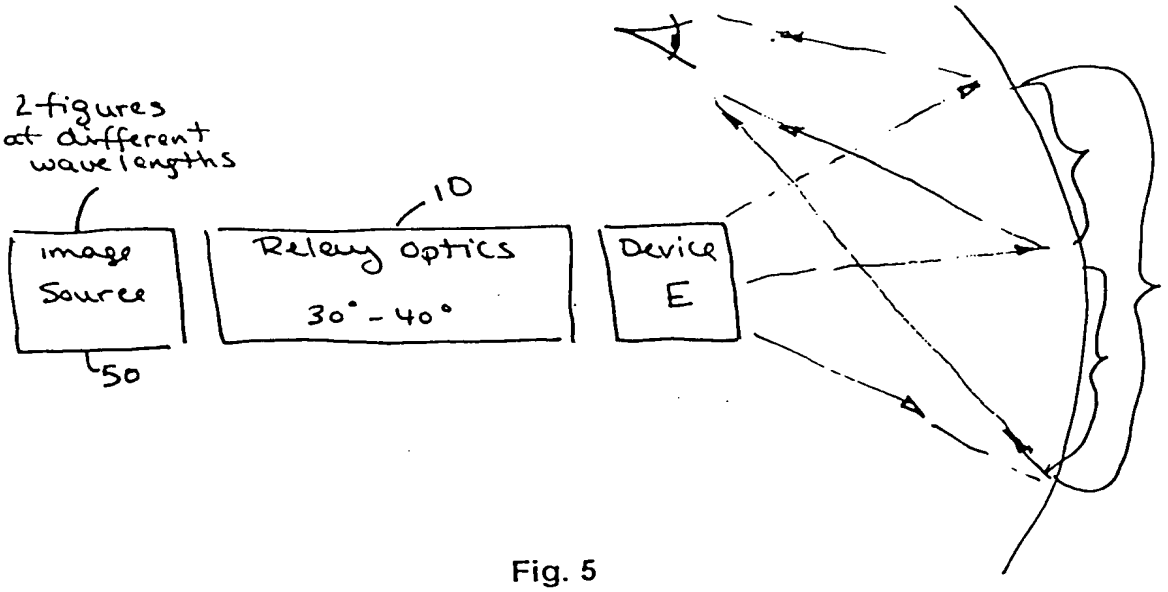


Fig. 5

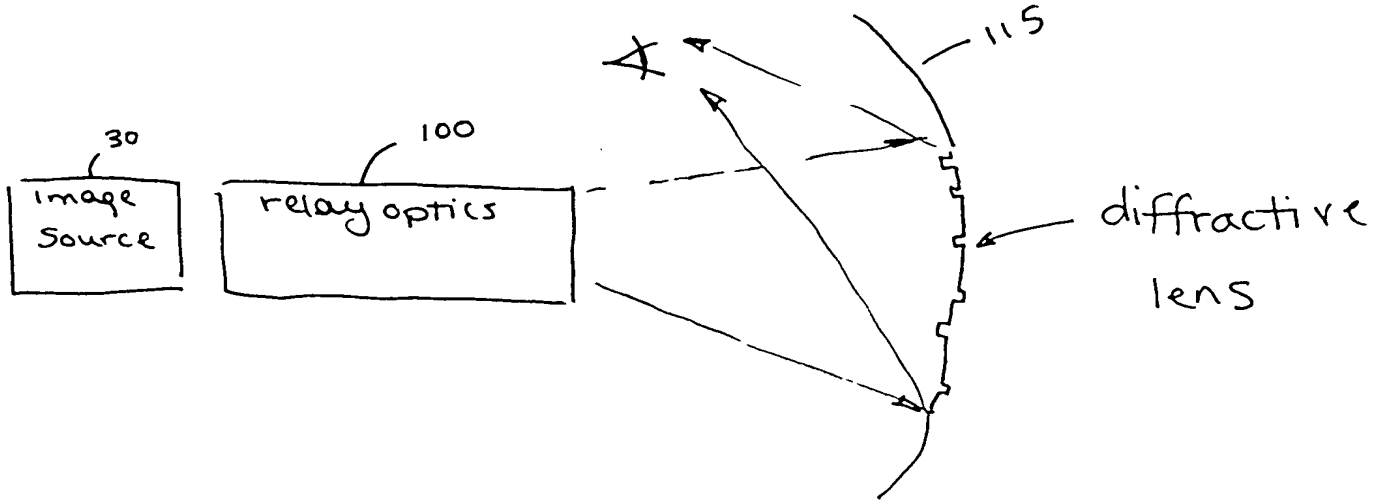

115
30
100
Image Source
relay optics
diffractive lens

Fig. 6

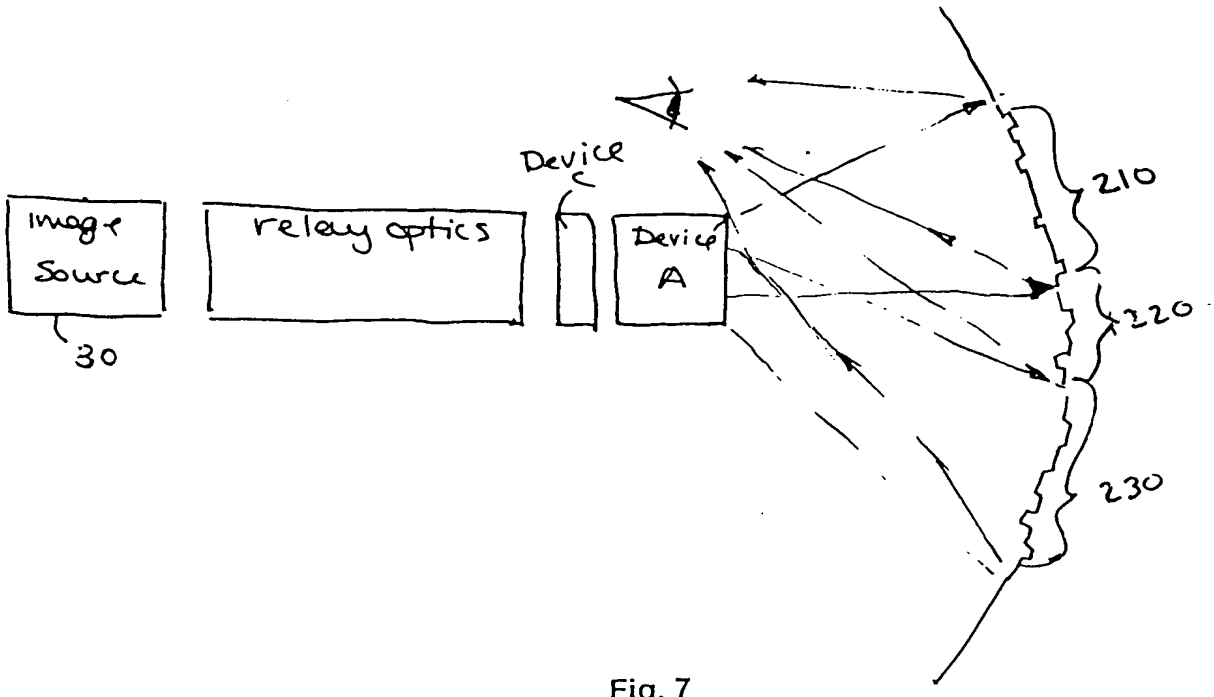

Device C
Image Source
relay optics
Device A
30
210
220
230

Fig. 7

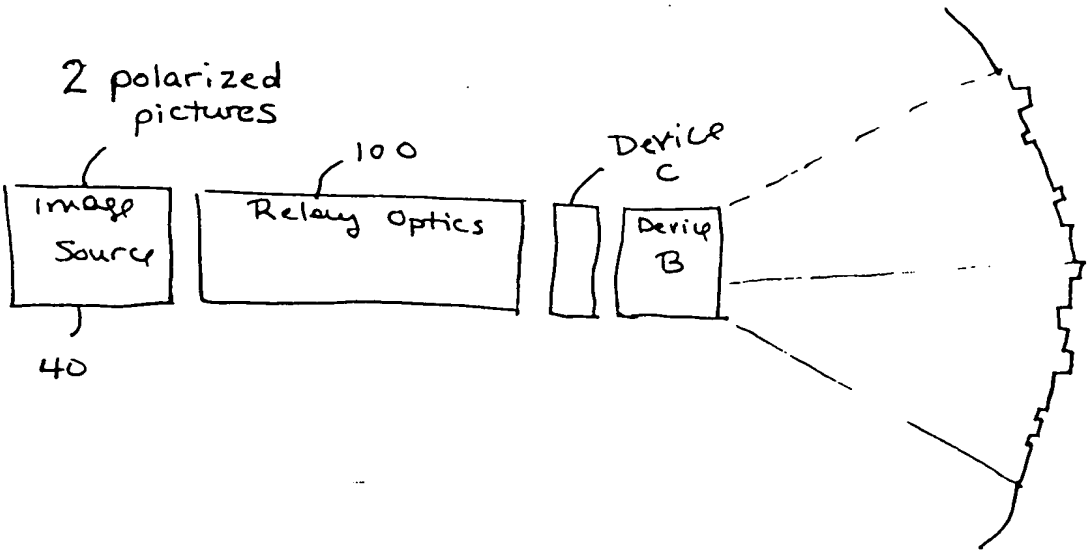

2 polarized pictures
100
Device C
Image Source
Relay Optics
Device B
40

Fig. 8